tion, yet such, within the limits described in the memoir, is an actual fact. The first essential point to be observed is the length of path of the spark; the most suitable distance apart of the platinum terminals appears to be between two and a half and three millimetres, and Prof. Hofmann advises the use of adjustable terminals rather than the ordinary platinum wires fused into the side of the eudiometer. A Leyden jar in the circuit renders the occurrence of periodical explosions more certain. The spark should also pass at about a quarter the height of the gas column instead of, as usual, near the top. The current itself, moreover, should not be too strong; that from two Bunsen cells and only a moderate sized Ruhmkorff coil is quite sufficient, and yields the best results. It is also preferable to use a volume of carbon dioxide, previously dried over oil of vitriol, not exceeding ten cubic centimetres at a pressure of 650–700 mm.; eight c.c. give excellent results. Under these conditions the first explosion usually occurs in 15–20 minutes, and sometimes earlier. The flame commences in the neighbourhood of the spark, and then perceptibly spreads through the whole length of the gas column. It is coloured blue in the first explosion, and green in the succeeding ones owing to the volatilization of a little mercury vapour. The second and succeeding explosions occur after shorter intervals than the first. This experiment is certainly one of the most interesting in all the range of dissociation phenomena, and full details, with drawings of the apparatus, are given by Prof. Hofmann in his memoir.

THE additions to the Zoological Society's Gardens during the past week include an Ocelot (*Felis pardalis*) from South America, presented by Mr. J. H. Bennett; a Common Fox (*Canis vulpes* ♀) from North Wales, presented by Mr. B. Myddelton Biddulph; two Cape Zorillas (*Ictonyx zorilla* ♀ ♀) from South Africa, presented by Mr. R. Southey; two Ring-necked Parakeets (*Palæornis torquatus*) from India, presented by Miss S. L. Hands; ten Thunder-fish (*Misgurnus fossilis*) from the Baltic Sea, five Golden Orfe (*Leuciscus orfus*), European fresh waters, purchased.

OUR ASTRONOMICAL COLUMN.

THE VARIATIONS IN LATITUDE.—The most important question discussed at the International Conference on Degree Measurement held at Freiburg on September 15 was that of the variability of terrestrial latitudes. The Central Bureau, represented by Drs. Helmert and Albrecht, communicated two notes, one by Dr. Albrecht, "Resultate der Beobachtungsreihen betreffend die Veränderlichkeit der Polhöhen," the other by Dr. Marcuse, "Resultate der fortgesetzten Berliner Beobachtungsreihen betreffend die Veränderlichkeit der Polhöhen." These papers, and a general account of the whole question of variation in latitude, first raised by Prof. Fergola at the Conference of Rome (1883), is given by M. Tisserand in the *Bulletin Astronomique* for September. The method adopted in the observations made at the different stations is that of Horrebow. It consists in forming nine groups, each containing eight or nine couples of stars, two groups at least being observed each evening. The two stars of each couple were of almost equal magnitude; their difference in right ascension was comprised between 3m. + 15m., and that of their meridian zenith distances between ± 12′, whilst the meridians were never separated more than 27°. By choosing such stars, and taking the arithmetical mean of the differences of zenith distances of the two components, the small error due to an imperfect knowledge of the movement of the micrometer wire is eliminated. At each station a number of couples of stars ranging from 1400 to 1700 have been observed during the whole of 1889 and the first three months of 1890. It is evident that if the same couple of stars could be observed throughout the year, during the day as well as the night, the variations in latitude could be obtained independently of the errors of the absolute declinations of the two stars, provided that we knew exactly the variations of these declinations during the whole interval of observation. These variations depend on the motion of the terrestrial axis (precession and nutation), on aberration, annual parallax, and proper motion. It is impossible to work in this way for two reasons, (1) stars cannot be observed in the day-time by means of the instruments employed; (2) only a very small number of observations could be made. The groups of stars referred to above have been formed in order to avoid these inconveniences, for the differences, from the mean declinations, of each of the couples may be used as if only a single couple had been observed. When the necessary corrections are applied to the calculations it is found that the latitudes of Berlin, Potsdam, and Prague, indicate clearly a diminution of about 0″·5 from August 1889 to February 1890. The observations made at Berlin from April 15 to August 30 in this year show an increase of 0″·4 in the latitude of this place during the interval considered, and point to a period of about a year. The fact that the latitude of a place is subject to an annual periodic variation is not entirely new, for Gaillot discussed 1077 observations of latitude made between 1856 and 1861. On arranging the observations according to the month in which they were made, the following differences from the mean value were obtained (*Annales de l'Observatoire de Paris*, p. 319):—

	Paris.	Potsdam.		Paris.	Potsdam.
	″	″		″	″
January ...	−0·23 ...	−0·11	July	+0·25 ...	+0·19
February...	−0·06 ...	−0·07	August ...	+0·16 ...	+0·17
March ...	−0·03 ...	−0·04	September	+0·13 ...	+0·10
April... ...	−0·03 ...	0·00	October ...	−0·07 ...	−0·03
May	+0·10 ...	+0·05	November	−0·11 ...	−0·14
June	+0·16 ...	+0·14	December	−0·27 ...	−0·26

These observations, therefore, indicate a difference of almost half a second between the observed latitudes in January and July. M. Nobile has discussed, from the same point of view, the observations made at Greenwich, Milan, Oxford, Pulkova, and Washington (*Bulletin Astronomique*, vol. v. p. 544). The Greenwich observations show a maximum of latitude in July and August, and a minimum in December and January, the amplitude of the variation being nearly 1″. At Washington a minimum also occurs at the end of the year, but at Milan it occurs in May. The Oxford observations show a maximum in the autumn, whilst those made at Pulkova do not appear to present any periodic variation with the seasons. But although these results are somewhat contradictory, those communicated at Freiburg clearly demonstrate the existence of a variation of 0″·5. It remains to be seen how the amplitude and the phase of the variation is affected by passing from the northern to the southern hemisphere, or when observations are made at two stations having appreciably the same latitude, but widely separated in longitude.

The cause of the variation has yet to be found. M. Tisserand has shown ("Traité de Mécanique céleste," vol. ii. p. 489) that the transportation of a mass of water, 0·10m. thick, from latitude + 45° to − 45°, and covering a tenth of the earth's surface, may cause the principal axis to move 0″·16. The weight of a column of water 0·10m. thick, is equal to that of a column of mercury 0·007m. thick, hence considerable changes in the barometric pressure may have an appreciable effect on the direction of the earth's axis. That the variations are connected with the succession of the seasons is manifest. This seems to indicate that temperature plays an important part, and that the variation is a result of the varying amount of heat received throughout the year by the atmosphere and the instruments. The theories of refraction require the atmosphere to have a regular constitution and a statical condition that is probably never realized. If the constitution varies with the season, the refractional effect must also change, and this may cause the difference in the observations of latitude.

Another probable cause was suggested by M. D. Lamey at the meeting of the Paris Academy on November 17. He showed that if the atmospheric tidal effects be calculated for each month in the year, the values obtained followed a curve very similar to that derived from the observed differences in latitude. That the sun and moon produce atmospheric tides must be incontestable. The physical consequence is that refraction phenomena must also vary with the tidal effect, and therefore the positions of stars may experience an annual periodic fluctuation comparable with that observed. The cause wherein lies the solution of the problem can only be definitely determined, however, after a more extended study than has yet been made.

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NEW ASTEROIDS.—M. Charlois discovered the asteroid (298) on September 9. On October 3, what was supposed to be the same body was again observed by Charlois. Dr. Palisa also observed an asteroid near the computed position of (298) on October 11. It has since been found that the observations of October 3 and 11 must refer to another asteroid, and, as Dr. Palisa discovered (299) on October 11, the one thought to be identical with (298) will be reckoned as (300). M. Charlois rediscovered (298) on November 14. Dr. Palisa added (301) the list on November 16 (*Astronomische Nachrichten*, 3006).

The large number of asteroids now known renders it impossible for the Berlin Computing Bureau to furnish all the data for their observation. The editors of the *Berliner Jahrbuch* have therefore decided only to furnish predictions for the following asteroids :—

(1) Those that approach near the earth, and are therefore well adapted to the determinations of parallax.

(2) Those whose near approach to Jupiter renders them useful for determining his mass.

(3) Those remarkable for a period having a closely commensurable ratio to that of Jupiter ; such orbits being of the highest importance in the theory of absolute perturbations.

(4) Those that are of value for photometric work on account of their considerable brightness.

ZONA'S COMET (*e* 1890).—Dr. Bidschof gives the following elements and ephemeris of this comet in *Astronomische Nachrichten*, 3006 :—

T = 1890 July 25·051 Berlin mean time.

$$\left.\begin{array}{r} \omega = 321^\circ\ 58' \\ \Omega = 84\ \ 45 \\ \iota = 153\ \ 28 \end{array}\right\} \text{Mean Eq. 1890.}$$

Perihelion distance = 1·8996 (earth's mean distance = 1).

Ephemeris for Berlin Midnight.

1890.	R.A. h. m.	Decl. ° ′	Distance in terms of the earth's mean distance.
December 4	3 47·0	+ 34 50	1·53
,, 8	3 26·8	+ 34 19	1·59
,, 12	3 8·7	+ 33 36	1·65

The comet is, therefore, in the constellation Perseus, which is in the south about 10 p.m. It passed perihelion about the end of July, and is increasing its distance from the earth. M. Bigourdan, of Paris Observatory, describes the comet as "très faible (grandeur 12·5–13), et se présentait sous l'aspect d'une petite tache blanche, ronde, de 1′ environ de diamètre, avec condensation central assez diffuse et d'aspect un peu grande."

THE SCIENTIFIC WORK OF JOULE.[1]

PROF. DEWAR commenced by remarking that the Royal Institution had been so closely identified with the great workers in physical science that it was impossible to allow the work of Joule, whose researches had produced as marked a revolution in physical science as Darwin's in biology, to pass without recognition in the present series of Friday evening discourses. Sir William Thomson, as Joule's friend and fellow-worker to the last, had been invited to undertake the duty, and had agreed to do so ; but at the last moment had been compelled to decline by reason of important official duties in Scotland, and the task had consequently devolved upon him.

Having given a brief account of Joule's parentage, early life, and education, Prof. Dewar reviewed, as fully as time would permit, his scientific work, which extended over about forty years, and was represented by 115 original memoirs. The first period (1838-43) was distinguished as that in which Joule educated himself in experimental methods, chiefly in connection with electricity and electro-magnetic engines. This work led him in 1840 to his first great discovery, the true law governing the relation between electric energy and thermal evolution, which enabled him later on to account for the whole distribution of the current, not only in the battery in which it is produced, but in conductors exterior to it. Joule was thus led to take up the study of electrolysis. Faraday had already made the discovery that electrolytic bodies could be split up into equivalent proportions by the passage of the same electric current ; Joule saw that there would be great difficulty in finding out the distribution of the current energy, and accounting for the whole of it. After a laborious research he succeeded in showing that during electrolytic action there was an absorption of heat equivalent to the heat evolved during the original combination of the constituents of the compound body. The prosecution of his electrical researches rapidly brought Joule on the road to his great discovery of the mechanical equivalent of heat, it being clear from a footnote to a paper dated February 18, 1843, that he already had well in hand the study of the strict relations between chemical, electrical, and mechanical effects.

In working out these laws, it was to be remarked that Joule—in common with most inventors and seekers after new scientific truths—chose perhaps the most difficult means that could have been selected ; and in looking back at his work in the light of present knowledge, it seemed simply astounding that he should have succeeded so completely as he did. The original coil used by Joule for the mechanical determination of heat (kindly lent for the occasion by Prof. Rücker) was shown, and the course of the experiment explained. The vast difficulties which Joule had to overcome in order to prove that there was a definite, permanent, and persistent relation between the amount of mechanical energy expended and the heat produced were commented on ; the thermal effects being produced not directly but through the medium of an electric current varying in intensity, and calculations having to be made not only for these fluctuations, but for the effects of radiation, the movement of the air, and other indirect complications. The very small increment of heat to be measured obliged Joule to use thermometers of great delicacy, and these he had to devise and construct himself. One of the thermometers so used was exhibited.

Working in this way, Joule was able, by the end of July 1843, to state definitely that the amount of heat capable of increasing the temperature of a pound of water by 1° F. was equal to, and might be converted into, a mechanical force capable of raising 838 lbs. to the height of 1 foot. Soon afterwards he attained almost identical results by a more direct method—the friction of water passing through small tubes—which gave him 770 foot-pounds per unit of heat.

It was impossible, said the lecturer, to thoroughly appreciate Joule's work without glancing at the early history of the subject ; and when one did so it was amazing to find how near men of the stamp of Rumford, Davy, and Young had been to Joule's great discovery, and yet missed it. Count Rumford was the first to clearly define the relation between the constant production of heat and loss of movement by frictional motion. He proved that the amount of heat produced by friction was continuous, and apparently unlimited ; but he did not think of measuring the relation between the mechanical energy expended and the amount of heat produced. Alluding to the results obtained from this apparatus, the lecturer said that Count Rumford might have shown that in his experiments the heat produced was proportional to the time of working, and so obtained a result capable of being expressed in horse-power. The value so deduced from Rumford's experiments is not far removed from Joule's first number.

The experiments commenced by Count Rumford were carried on by Davy, at that time working with Beddoes at Bristol ; and led to one of the most remarkable essays on heat of that period, which disposed for ever of the theory of the separate existence of caloric. Taking two pieces of ice on a cold day, Davy mounted them so that they could be rotated against each other with frictional pressure, the effect being that the pieces of ice were melted, the water so produced having a much higher specific heat than the original ice. To guard against the possibility of heat being conveyed to the frictional apparatus by the surrounding air, Davy made an experiment *in vacuo*, isolating the apparatus by means of ice ; and found that under such conditions sufficient heat could be produced to melt wax placed in the receiver. The lecturer here showed an experiment illustrating the production of water by the friction of two pieces of ice *in vacuo*, under conditions of temperature much much severe than those of Davy's experiment.

Following Davy, Young devoted a great deal of attention to the subject, and by 1812 he and Davy had quite changed their opinions, and had adopted the view that heat and motion were convertible effects.

Having by July 1843 assured himself of the principle of his discovery, Joule now devoted his attention to the elaboration of methods of working, modifying, and repeating experiments in

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[1] Abstract of the Friday evening discourse delivered at the Royal Institution of Great Britain on January 24, 1890, by Prof. Dewar, F.R.S.

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